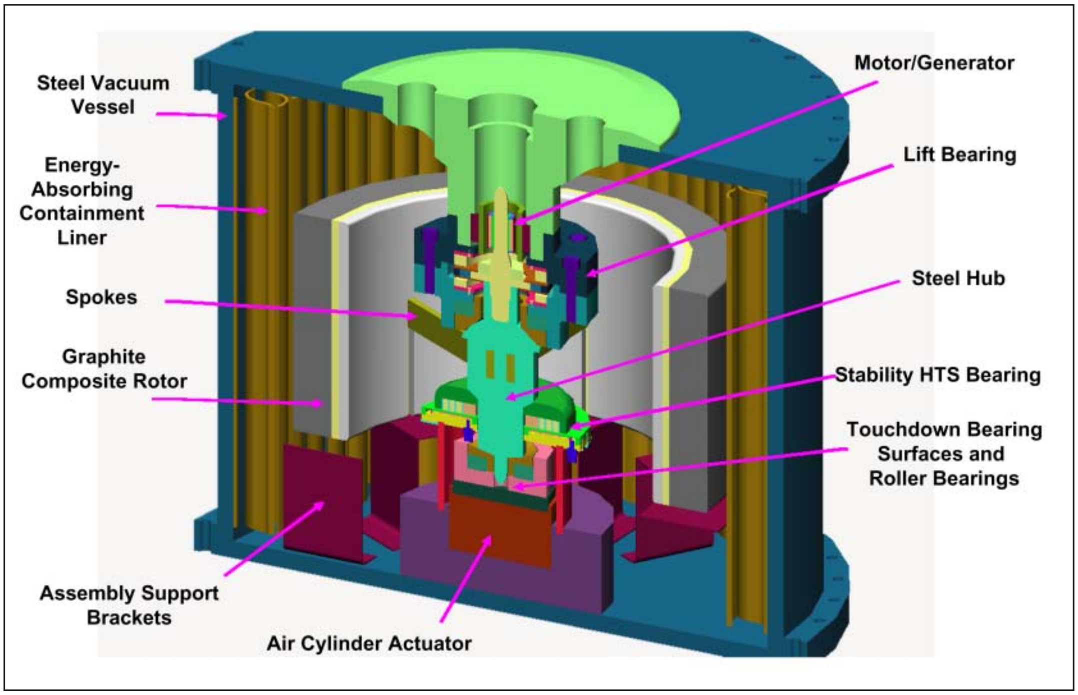
Flywheel Electricity System

P R O J E C T • F A C T • S H E E T

SPI Projects are Co-Funded by the U.S. Department of Energy
Superconductivity for Electric Systems Program and Industry Partners

Superconductivity Partnership with Industry



Schematic of the 10 kWh HTS flywheel design, showing the essential elements. (Boeing)

What Are Its Primary Applications?

Flywheel electricity systems can be applied to increase electric utility efficiency and reliability in two areas—electric load leveling and uninterruptible power systems (UPS) applications. As an energy storage device, flywheel systems can transform electric energy into kinetic energy via an electric motor, store the energy in the rotation of the flywheel, and use the rotational kinetic energy to regenerate electricity as needed.

The primary application of this technology is load leveling. The flywheels can eliminate both momentary voltage and frequency changes and longer-term power interruptions. Flywheels can also be used to "smooth" the fluctuations that result from load following, which allows power plants to operate more efficiently.

Secondary use of the HTS flywheel electricity system will focus on UPS applications, which provide short-term power in the event of a grid failure. Project efforts toward this downstream application will include developing a more rugged HTS bearing and a high output motor/generator (up to 100 kW) to allow a 5 to 10 minute discharge of stored energy.

This new project will result in a full-scale flywheel system that will allow power users and utilities to better manage both cost and reliability risks through strategic location and use of the systems.

What Are The Benefits To Utilities?

Flywheel electricity systems have the potential to provide increased system flexibility and efficiency through load-leveling, maximizing system potential, and reducing electricity waste. Traditional flywheel designs have been prohibitive in all but the most specific applications, because of friction and complex control systems resulting in energy losses of at least 3 to 5% per hour. Compared to traditional rolling contact or conventional electromagnetic bearings, HTS bearings will provide dramatically reduced frictional and parasitic load losses; HTS bearings have demonstrated energy losses of less than 0.1% per hour.

The UPS applications of the flywheel electricity systems have

Goal:

To develop and test a 35 kWh flywheel electricity system for utility power risk management applications. High-temperature superconducting (HTS) bearings are an enabling technology.

Team:

Boeing Phantom Works (team leader)

Argonne National Laboratory (supporting research)

Ashman Technologies (motor/generators)

Praxair Specialty Ceramics (refrigeration and process engineering)

Southern California Edison (utility end-user)

Period of Performance:

2002–2005

Cumulative Project Funding:

Private $8.0 million (51%)
DOE $7.8 million (49%)
Total $15.8 million

What is it?

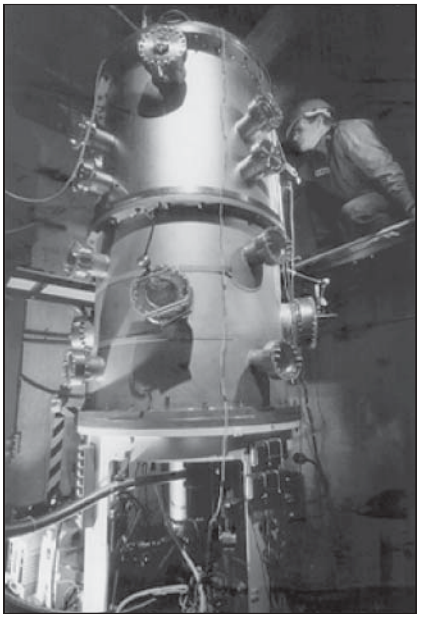
Flywheel electricity systems store electric energy as rotational kinetic energy for future use.

FLYWHEEL ELECTRICITY SYSTEM

P R O J E C T • F A C T • S H E E T

SPI PROJECTS ARE CO-FUNDED BY THE U.S. DEPARTMENT OF ENERGY
SUPERCONDUCTIVITY FOR ELECTRIC SYSTEMS PROGRAM AND INDUSTRY PARTNERS

Superconductivity Partnership with Industry



A technician works on a vacuum chamber used to test flywheel components at Argonne National Laboratory.

the potential to save both utilities and consumers millions of dollars in time and work losses. A survey by Pacific Gas & Electric found that 2% of large industrial consumers face losses exceeding $1 million with each interruption of power. These systems have the capability to significantly reduce or eliminate this type of loss by providing consistent, high quality power.

Flywheel electricity systems will prove especially effective at these applications in distributed power systems, meeting high demand at the load center and providing power that is locally non-polluting and efficient.

WHAT IS THE MARKET POTENTIAL?

Utilities presently spend millions of dollars per year on pumped storage and other power and cost management techniques. Flywheel electricity systems will penetrate a significant portion of this market by offering improved efficiency at a comparable cost. Large industrial consumers interested in maintaining power quality at reasonable costs represent another huge potential market for flywheel systems. These systems could replace or augment the multi-million dollar standby diesel generator market.

WHAT ARE THE PROJECT ACCOMPLISHMENTS TO DATE?

Boeing and the Department of Energy teamed up on two earlier projects that led to the development of a 2 kWh laboratory flywheel system and a 10 kWh flywheel electricity system. Testing on the 10 kWh system is continuing. The agreement to develop the 35 kWh flywheel electricity system for power risk management was finalized in late 2002, and conceptual designs are underway.

HOW DOES IT WORK?

Flywheels have been used to store energy since the invention of the potter's wheel. The less friction in the wheel bearings and the less air resistance on the flywheel, the more efficient its energy storage capability. By attaching a motor/generator to the wheel, electricity can be converted to kinetic energy by the motor, then recovered later by converting the rotation of the flywheel to electricity using a generator. Until the recent development of bulk superconducting, self-centering HTS bearings, the energy loss associated with both mechanical and electro-mechanical bearings has been prohibitively high. Actively-controlled electromagnetic bearings reduce this problem due to their non-contact nature. Unfortunately, these systems face significant problems including scaling to utility sizes, high costs associated with complex control systems, and standby energy losses. With the development of efficient bearings based on high-temperature superconductors, losses can be reduced to less than 0.1% per hour while maintaining a stable bearing for the rotating wheel.

The key to a stable superconducting bearing is a strong response of the chilled superconductor to changes in the field pattern of a rotating permanent magnet assembly placed above the superconductor. Rotational motion is "allowed" and takes place with very little drag, because the magnet assembly provides a circumferentially symmetric field pattern. Only when the rotor moves away from its rotational center are restoring forces generated by the super currents in the stationary HTS ring.

The flywheel is mounted in a vacuum vessel, either fitted with a vacuum pump or hermetically sealed, to reduce frictional losses.

WHAT IS THE STATUS OF THE PROJECT?

Testing of a 10 kWh flywheel system developed in an earlier cooperative project with DOE is continuing.

A follow-on project was recently awarded to Boeing, and conceptual designs for the 35 kWh power risk management system are in the early phases.

Information Contact: Mike Strasik • Boeing • 425-237-7176
Imre Gyuk • U.S. Department of Energy • 202-586-1482

Revision date: 01/13/03